or can be made the subject of experimental investigation. To what extent the colloidal substances of cells, such as the mucilage dissolved in the sap, can be made use of, and how this use may be modified by the acid or alkaline content of the disperse medium is at present almost or quite unknown. The great size of tannin idioplasts and the imbibitional avidity of their colloidal content may, it is quite possible, be related, and it is similarly possible that the growth and therefore the size of other cells may depend not only on the "turgor" relations, but even more upon the imbibition pressure exerted upon their walls. The mucilage and other colloidal content of desert succulents *par excellence* may in this light take on greater significance in view of Borowikow's work, cited by MacDougal.

Much more of detail from this collection of papers could be given with more ease than to indicate, without giving an impression of meagerness in the source, the most salient points. Many people untaught in the thought of the scientist have expected vast changes in the surrounding country to follow the flooding of a large desert-inclosed area. The emersed bed of Blake Sea is, however, still a desert, and as measurement and even more superficial observation shows, the evaporation from the many square miles of water surface has had no smallest effect upon any vegetation but that immediately following recedence of the water itself. A very short span of time and the desert is restored to its own. But the opportunity of seeing what does happen has fortunately been seized, and we have in this review seen, it is hoped, that a result of signal value has rewarded.

FRANCIS E. LLOYD

MCGILL UNIVERSITY

SCIENTIFIC RESEARCH AND SIGMA XI[1]

BEFORE the chapter reports are presented, it is my business for twenty minutes to address you, yours to listen; for Sigma Xi too expects every man to do his duty. We have eaten; water has been served; it is a pity that we can not now be merry. For whatever may happen to us, Sigma Xi will not die to-morrow. We have long since passed through the dangerous period of infancy; at the age of twenty-seven the death-rate is but five per thousand. And we surely are a chosen people; like the patriarchs of old, the years of our life are measured not by decenniums but by centuries.

Our first quarter century has indeed been a period of marvelous growth and fruition. As exhibited in the record and history admirably compiled by our secretary, it is one of the fairy tales of science, incredible if it were not true. The beginnings at Cornell University were small, but, like the zygote, they contained the elements which in interaction with a fit environment grew into the great organism, of which each of us is one seven-thousandth. Unlike the individuals of the species to which we belong, our corporate growth does not stop at the age of twenty-five, nor will senility follow fifty years of activity.

In a recent article an eminent American statistician states that 30.7 per cent. of Rhode Island native-born married Protestant mothers are childless. The distinguished dean of a great woman's college within a thousand miles of Philadelphia in a chapel address to the students said that it is not just to charge the decreasing birth rate to the higher education of women; although the college had been established only a few years, forty per cent. of its alumnæ were married and sixty per cent. of them had children. When birth-rate statistics are so complicated, it may not be safe to state that we are all the children of Henry Shaler Williams. But this is true, though polyandry appears on the records and we have certainly had polygamous nursing. We may indeed regard our leaders and each of us as somas of the immortal germ plasm, which seeks the light of truth:

> That light whose smile kindles the universe,
> That beauty in which all things work and move.

As a hand apart from the body is not a hand, as a man apart from other men is not a man, so a scientific man is not conceivable

[1] Remarks by the president of the Society of the Sigma Xi at the annual dinner given at the University of Pennsylvania on January 4, 1915.

apart from the long line of scientific worthies, great and small, who have bequeathed to us our present heritage, or from his fellow workers, old and young, without whose sympathy and cooperation no research would be possible. Our society has been founded to personify and promote the spirit of comradeship and zeal which is essential to scientific research. A century earlier, Phi Beta Kappa was established to encourage and reward scholarship in our colleges. It may be desirable to maintain the tradition of classical learning, but as service is better than culture, as the future is of greater concern than the past, so creative science is more than passive scholarship.

The activities of Sigma Xi with which I have indeed least sympathy are those which we have inherited from Phi Beta Kappa. It is a pity that we did not find an honest English name. How many of us know whether Ξυνῶνες means companions, or zealous or research? I happen to be one of the small minority of our members who read Greek for professional purposes after leaving college, but I do not know the orthodox way to pronounce our initials. In the presence of these modern Greek mysteries, one feels like the little girl who, being sent to school for the first time, rushed home on hearing the older boys recite: At 'er, beat 'er, jam 'er, eat 'er.

A pendant gold key suitably engraved is too reminiscent of the dueling scars on a face made and marred in Germany, a personally conducted advertisement of a past university student and presumably member of a corps. It has been suggested that the proposed class of associates might be entitled to wear only a smaller key. Why not let the professor carry one three inches long, and if he should become a president, make it a foot long, even though four to one would inadequately represent the difference in eminence and ability to pay for the gold? The badge may be a convenient way to pick up a congenial acquaintance in a smoking car; but would it not be better to wear a more extended label to the effect that I am not only Sigma Xi and Phi Beta Kappa too, but also a teacher of psychology, interested especially in science, education and democracy, but ready to talk about almost anything except golf and psychical research?

It is better to select and distinguish students for promise or performance in research than for high grades in classes. If interest in research or scholarship can be stimulated by such rewards they are legitimate. But when we embroider with gold braid, we are likely to bind with red tape. I wonder whether a single piece of research work has been conducted or improved because it might lead to election to the National Academy of Sciences or to an honorary university degree. The University of Königsberg has conferred the degree of its four faculties on General von Hindenburg for driving the enemy from the gates of the city, but it may be doubted whether even the doctorate of divinity will be of great assistance to him in checking the invasion. Like old china or other bric-a-brac in a laboratory, all such inherited and artificial distinctions are out of place in a democracy. If members of the National Academy received a salary for useful services, or if membership in Sigma Xi enabled students to go on with their researches then the election would be useful and desirable. It would from my point of view be better if membership in Sigma Xi depended on the option and efforts of the student and the scientific man, such as attendance at meetings and the presentation of a paper.

Even the separation of the academic sheep from the philistine goats does not seem to be a desirable segregation. A college and university education is certainly at present the gateway through which they must pass who wish to follow the paths of scientific research. But from some points of view, this is an evil necessity rather than an ideal condition. It is costly in money and precious years, in initiative and originality. The two greatest scientific men whom we have known, Simon Newcomb and William James, did not enjoy or suffer the orthodox college or university education; the same is true of the two living Americans responsible for the most important applications of science—Mr. Edison and Mr. Bell. If two academic degrees were required —four years of college culture and four years

of professional training—before the poet, the novelist, the musician, or the artist could become productive, what would be left of the literature and the art of the world? It is a system of privilege when only those can enter the professions whose parents are able to support them to the age of twenty-seven years; it postpones too long family duties and civic responsibility, and those who travel long over well-worn ways may accumulate baggage and habits which burden rather than help the exploration of new territory.

Your to-night's figurehead has been accused of being habitually "again the administrashun," but in intention at least he is radical only as to ends, while reasonably conservative as to means. Our Society of Sigma Xi, like the university of which it is a part and much else that is best in our civilization, is a heritage handed down to us from other days and other ways, only partly adjusted to a democracy in the twentieth century. Institutions and customs should not be bent until they break; they should be permitted to reach toward the light by their own gradual growth. We can not live in a true democracy until it exists, and in the meanwhile we must do the best we can with our inherited institutions and human nature. Our society has in several directions led the way—in placing research before high grades in class work, in uniting those showing the beginnings of aptitude for research work with productive scientific men, in emphasizing and promoting the comradeship and common interests of scientific workers, in arranging scientific meetings and lectures to which all are welcome, in putting applied science on terms of equality with other research, lastly and chiefly in being one of the active agencies contributing to scientific advance.

It is anti-democratic to hold that culture is precious because it can be attained only by those having wealth and leisure, that science is noble only when it is useless. The mathematician who thanked God that his geometry was a virgin that had never been prostituted by being put to any use did not stay in America longer than he could help. Pure science may proceed on a long orbit, but it can not go off on a tangent to the real things of life. Our society has served both science and democracy by placing engineering on terms of equality with other sciences. The distinction is not between scientific discovery and practical applications, but between the discovery of new truths or new ways of doing things and the repetition of those already learned; not between the pathologist who studies diseases and the one who finds cures, but between the experimental pathologist and the routine practising physician; not between the engineer who builds bridges and the one who writes about bridges, but between the scientific man who devises new methods and the builder who copies old models. Adopting what Francis Bacon wrote in another connection:

> These two subjects, which on account of the narrowness of men's views and the traditions of professors have been so long dissevered, are, in fact, one and the same thing, and compose one body of science.

And most of all, this Society of the Sigma Xi has served democracy and science by emphasizing research work at the outset of the student's career and as the essential life work of each of our members. It is our business to promote scientific research by every method and by every motive. A correct statement of the economic value of science to society would at first sight seem incredible. It is safe to say that the applications of science have quadrupled the productivity of labor and doubled the length of human life, though it is not possible to give the exact period from which this result is reckoned. The writer would guess that so much progress has been made within from one hundred to one hundred and fifty years. In some kinds of work, as in the transportation of freight over land and some kinds of machinofacturing, the efficiency of labor has been increased a hundredfold; in others, as in agriculture, it may have been only doubled. In the period during which the efficiency of labor has been quadrupled by modern science, the annual production of wealth in the civilized world has perhaps been increased a hundred billion dollars, representing

a capital sum of two thousand billion dollars.[2] A great part of this advance is due to a few men, probably one half of it to, at most, 10,000 men. The value of each of these men to the world has been a hundred million dollars; they have been men not abler nor more productive on the average than the upper five hundred of our leading American men of science.

So far from being exaggerated this valuation of science and of scientific men neglects the decrease of disease and suffering, the increased length of life and the vast number of human beings for whom life has been made possible. It can not take account of the moral, intellectual, political and social changes wrought by science and its applications. Science has made democracy possible and has given us as much of it as we have. The applications of science have abolished the necessity of continuous manual labor from childhood to old age, they have made feasible universal education, equality of opportunity and equality of privilege, they have banished legal slavery, they have partly done away with the labor of children and the subjection of women. Science has given us freedom in the moral as well as in the material world, freedom from ignorance, superstition and unreason, the means of learning the truth and the right to tell it.

The service of science for the world is by no means complete. The productivity of labor can be again doubled by further scientific discovery; it can be more than doubled by the selection of the right men for the work they do and by correct methods of work. The value of wealth can be doubled by its proper distribution and use. Warfare, preventable disease and vice, waste and display, the futile complications of civilization, consume one half of all the wealth that is produced. We do not know the conditions of happiness and real welfare or how they are to be attained. Science should continue to press to the limit economy of production and the conservation of health and life; at the same time it should increasingly direct its methods to the control of human conduct.

[2] This enormous figure is based on the assumption that there are 25,000,000 people in the United States, whose productive work is worth on the average $1,000 a year and six times as many in the civilized world who earn on the average half so much, with enough left over to balance the earnings of 100 years ago.

Suddenly, out of its stale and drowsy lair, the lair of slaves,
Like lightning it leapt forth half startled at itself,
Its feet upon the ashes and the rags, its hands tight to the throats of kings.

On us here in America there has been thrust the duty and the privilege to carry forward the flickering torch of science and of civilization. Our society of the Sigma Xi and each of us have indeed great opportunity and great responsibility.

J. McKeen Cattell

RADIUM FERTILIZER IN FIELD TESTS

With the discovery of radio-activity by Becquerel, in 1896, and of radium itself by M. and Mme. Curie, in 1898, science revealed a property of matter and a source of energy hitherto unknown; and the facts already established, the predictions or claims made, and the general interest in the subject seemed to justify an investigation under field conditions of the possible value of radium as a fertilizer, or of radio-activity as a crop stimulant.

While possessing most of the properties of an element, reacting chemically very similarly to the element barium, radium also has the remarkable property of continuous disintegration, by continuous emanation of particles, which is accompanied by radiation of energy, called radio-activity.

Investigations show that one gram of radium emits enough heat to raise 118 grams of water one degree centigrade in one hour, or 118 calories, and indicate about enough total energy to decompose one gram of water into hydrogen and oxygen every twenty-four hours, equivalent to more than 3,800 calories, or nearly 160 calories per hour. This radiation continues hour after hour with gradual reduction to $\frac{1}{2}$ the quantity in about 1,760 years, to $\frac{1}{4}$ in